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Publication Date:	02/1996
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Bibliographic Code:	1996SPIE.2665...59S

Abstract

Barcode systems are used to mark commodities, articles and products with price and article numbers. The advantage of the barcode systems is the safe and rapid availability of the information about the product. The size of the barcode depends on the used barcode system and the resolution of the barcode scanner. Nevertheless, there is a strong correlation between the information content and the length of the barcode. To increase the information content, new 2D-barcode systems like CodaBlock or PDF-417 are introduced. In this paper we present a different way to increase the information content of a barcode and we would like to introduce the color coded barcode. The new color coded barcode is created by offset printing of the three colored barcodes, each barcode with different information. Therefore, three times more information content can be accommodated in the area of a black printed barcode. This kind of color coding is usable in case of the standard 1D- and 2D-barcodes. We developed two reading devices for the color coded barcodes. First, there is a vision based system, consisting of a standard color camera and a PC-based color frame grabber. Omnidirectional barcode decoding is possible with this reading device. Second, a bi-directional handscanner was developed. Both systems use a color separation process to separate the color image of the barcodes into three independent grayscale images. In the case of the handscanner the image consists of one line only. After the color separation the three grayscale barcodes can be decoded with standard image processing methods. In principle, the color coded barcode can be used everywhere instead of the standard barcode. Typical applications with the color coded barcodes are found in the medicine technique, stock running and identification of electronic modules.

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Designing Real-Time Vision Based Augmented Reality Environments for 3D Collaborative Applications

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Abstract

Augmented Reality (AR) is a variation of virtual reality. It allows the user to see computer generated virtual objects superimposed upon the real world through the use of some kind of see-through head-mounted display. Human users of such system can interact with the virtual world and have additional information, such as character description of physical objects and instruction for performing physical tasks in form of annotation, speech instruction, image, and 3D model.This paper describes our work of building a wireless augmented reality prototype, which supports video-based 3D graphics and a keyboard interface over wearable computers to interact with virtual objects. A new technique for identifying real world objects and estimating their coordinate systems is introduced. The method utilizes a Binary Square Marker, which can identify a great number of real world objects with markers tagged on them by using computer vision techniques.

Keywords: *Augmented reality; marker detection; collaborative application.*

1. Introduction

1.1 Background and motivation

From the human's perspective, the real world is composed of the physical materials that people can feel by their own senses. The information people get from their senses is very limited in some circumstances and extra information augmenting the real world could overcome the limitations. For example, when a repairman wants to fix a pipeline in the wall, a virtual map of the pipeline, overlaid on the real scene of the wall, will save the repairman a lot of time to find the broken pipeline. Another example: without a tour guide in an art museum, information such as the background of the artist or the music of his/her time will help the visitors to understand the work of art.

Augmented Reality (AR) is used to describe a system, which enhances the real world by superimposing computer generated information on top of it. AR is a variation of Virtual Reality (VR). VR technologies completely immerse a user inside a synthetic environment. While immersed, the user could not see the real world around him. In contrast, AR allows the user to see the real world, with computer-generated information or virtual information superimposed upon or composed with the real world. Therefore, AR supplements reality, rather than completely replacing it. Combining virtual information with the real world in 3-D space is useful in that it enhances a user's perception of and interaction with the real world. In addition, the virtual information, such as annotations, speech instructions, images, video, and 3D models, helps the user perform real world tasks.

1.2 Existing problems in AR

In general, AR is a system that combines real and virtual, is interactive in real time, and is registered in 3D [1]. Two basic technologies are available to accomplish the combining of real and virtual. One is using head-mounted display (HMD) equipment with a wearable computer, the other is overlaying computer-generated graphic images on the camera captured video using the monitor.

Proceedings of the 2002 IEEE Canadian Conference on Electrical & Computer Engineering
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On Sensor Evolution in Robotics

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Abstract

In recent years, evolutionary algorithms (EAs) have been successfully used in the design of artificial neural networks for a variety of applications. The suitability of EAs for this design task stems from their ability to adaptively search large spaces in near-optimal ways. One direct application of this advance has been in the area of evolutionary robotics, where EAs are typically used for designing behavior controllers for robots and autonomous agents. While such designs have been found to work well in general, their performance is often limited by the number, placement, quality, efficacy, and reliability of the sensors that the robots are endowed with. In this paper we argue that designing the sensory systems of these robots, in addition to the usual practice of designing the controller, can lead to improvements in the performance of the robot. Our results indicate that the evolution of sensors is a useful enterprise, and can lead to efficient and often counterintuitive controller designs.

1 Introduction

Robots and autonomous agents are equipped with control mechanisms that allow them to produce specific behaviors in any given environment. Not only must these control mechanisms be efficient and robust, but also able to adapt to a changing environment. *Artificial neural networks* are therefore viable candidates for such behavioral control mechanisms [7, 5, 2].

However, realizing even the simplest of robotic behaviors requires fairly complex trade-offs among several, often conflicting, objectives. For example, to implement *wall-following* behavior, a robot has to optimize multiple criteria like efficient sensing, recognition of the wall, reasonably precise estimation of the distance to the wall, maintenance of a safe distance to avoid bumping into the wall (while keeping it within sensor range), appropriate control of speed, etc. Thus, design of appropriate neural network controllers (or neurocontrollers) to realize such behaviors is an instance of a difficult multi-criterion optimization problem.

Evolutionary Algorithms (EAs), simulated models of natural evolution, have been shown to be effective procedures for searching large, complex, multi-modal, and deceptive spaces [8, 6], and can thus be employed to solve multi-criterion optimization problems like the design of neurocontrollers for robots and autonomous agents [9, 12, 5, 10, 3]

Although a large body of work exists in this area, most of them assume a fixed sensory system architecture, while concentrating only on the design and development of the control mechanism. For example, the miniature robot Khepera [11] was used in the navigation studies in [5]. Since Khepera comes equipped with eight infra-red (IR) sensors, the neurocontrollers evolved in [5], assumed the availability of eight IR sensors. Fewer (or more) sensors might have resulted in better performance, but that dimension was not explored.

The wide variety of sensory systems represented in nature are suggestive of the power of evolution in determining good designs over many such dimensions, including — sensors of different *types* (e.g., vision, tactile, olfactory etc.), *characteristics* (e.g., range, sampling frequency, response function etc.), *numbers* (e.g., two eyes, one nose etc.), *placement* (e.g., front, rear, top etc.), modes of *sensory information integration* (e.g., through the use of appropriate neural circuits), etc.

Just as specific designs of the sensory system provide the endowed biological organisms with a survival advantage, it is natural to wonder if the performance of robots and autonomous agents would benefit from similar sensory system design considerations. This paper attempts to answer this question by using evolutionary techniques to discover good designs of sensory systems.

2 The Simulation Task

The robotic simulation that we consider in this paper is based on a task proposed by Teller [13]. Here the robot is placed in a square arena of $N \times N$ cells, in which M boxes are randomly scattered in the inner $(N-2)\times(N-2)$ grid. The arena is enclosed by *impenetrable* walls as shown in Figure 1.

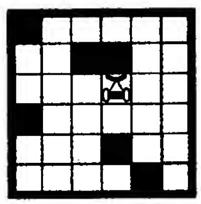

Figure 1: **The operating environment. Shaded squares represent boxes and unshaded ones, empty space.**

The robot is started off in a random position facing one of four directions — north, south, east, or west; with the task of clearing the arena by moving the boxes to the sides. As per the original specification of Teller, the robot has eight sensors which provide the robot with specific inputs so that it can detect the presence of boxes, walls, or empty spaces. The sensors are *fixed* to the robot (i.e., turn with the robot), and *sense* one square in each of the eight directions surrounding the robot. The robot determines its output action based on the information provided by the sensors, and possibly the history of its past actions.

The robot is capable of three possible actions — forward move, 90 degree anti-clockwise turn, and 90 degree clockwise turn. Turns are in-place, while move forward actions result in the robot moving ahead by one square. If there happens to be a box immediately in front of the robot when it moves forward, the box gets pushed ahead by one square. This is the primitive operation that the robot needs to clear the arena.

Attempts to push a box fail under two circumstances: the box may already be against a wall; or there may be another box adjacent to it in the direction in which the box is being pushed. The latter is tantamount to saying that the robot has the capacity to push *at most one* box at a time. The fitness of the robot is measured by the number of boxes it pushes to the walls within an allocated period of time. Our objective then, is to design a neurocontroller for this robotic bulldozer that allows it to attain a high fitness. We would also like to determine if the fitness might be improved upon by a judicious design of the number, placement, and range of sensors. For reasons mentioned in section 1, we use EAs to search for such designs.

3 Implementation Details

In our simulations we use *Genetic Algorithms* (GAs) [8, 6] to evolve sensory and neurocontroller designs. Our *genetic representation* had two parts, one encoding the placement and ranges of the sensors, and the other encoding the input connectivities of the units of the neurocontroller, as shown in Figure 2. The sensors were encoded using a 2-tuple (i, j), with the understanding that the corresponding sensor is placed to detect the square i cells *behind* and j cells to the *right* of the cell occupied by the robot. Thus, negative values of i mean the sensor is *frontal*, i.e., in front of the robot, while negative j's indicate that the sensor is positioned to the *left* of the robot. For example, a value of (-1,0) encodes a sensor that senses the square one cell to the *north* and zero cells to the *east* of the current position of a *north-facing* robot (labeled **N** in Figure 2). This sensor would detect the cell to the east if the robot turns clockwise through 90 degrees. (Henceforth, sensors will be labeled assuming a north-facing robot, with the understanding that the sensors turn with the robot.)

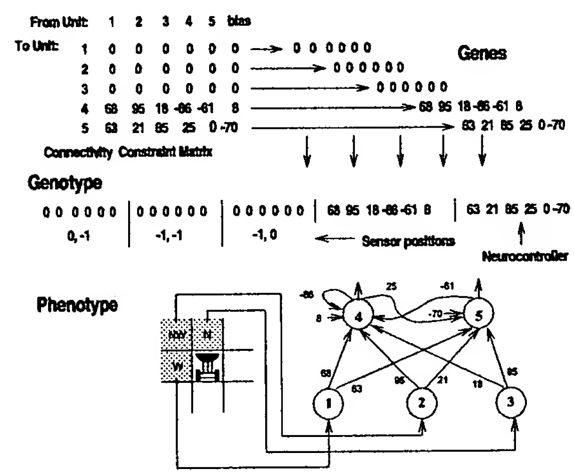

Figure 2: **Genetic representation used.**

The genetic operator *crossover* was defined to swap *logical blocks* (genes), where each block is the specification of either one sensor or one unit. *Mutation* was defined to randomly change values in the blocks, thereby producing changes in either the placement/range of sensors or in the input connections of a unit (depending on what the corresponding block encoded). Our simulations used populations of size 100, and the evolutionary runs lasted 100 generations. We used *uniform-crossover* with crossover probability of 0.5, and mutation with probability 0.1 per gene. The weights in the network were constrained to be *integers* in the range [-100 $\cdots$ +100], while sensor positions and ranges were bounded by the size of

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and outputs Y and RAND. The input registers are **shaded**, and X and Y are vector ports. For clarity,
i44ftp.info.uni-karlsruhe.de/pub/papers/weinhardt/raw97.ps.gz

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Figure 2: Side view of the NOMAD detector. The **shaded** regions are the iron magnet flux return yoke and
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vectors uniformly distributed in the **shaded** regions. The vectors were labeled A through E
ftp.cs.utexas.edu/pub/neural-nets/papers/blackmore.ml95.ps.Z

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to orientations of 0, 45, 90 and 135 degrees. The **shaded** region indicates the spectral support of a
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denote the key patterns presented in this paper. **Shaded** boxes are contained only in the PLoP Proceedings
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be replicated in static images. We therefore use **shades** of gray to indicate different VOFs in the
be horizontally aligned. The middle three nodes, **shaded** medium gray, are to be evenly spaced. Figure 8
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in Figure 1. Figure 1: The operating environment. **Shaded** squares represent boxes and unshaded ones, empty
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area of the respective uncertainty regions (the **shaded** region)M i t M j Figure 2: An illustration
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when the body is continuously but non uniformly **shaded**. Moreover, the shape of the body is emphasized as
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Tamper-Resistant Biometric IDs

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Abstract

We present FACECERTS, a simple, inexpensive, and cryptographically secure identity certification system. A FACECERT is a printout of person's portrait photo, an arbitrary textual message, and a 2-D color barcode which encodes an RSA signature of the message hash and the compressed representation of the face encompassed by the photo. The signature is created using the private key of the party issuing the ID. ID verification is performed by a simple off-line scanning device that contains the public key of the issuer. The system does not require smart cards; it can be expanded to encompass other biometric features, and more interestingly, the ID does not need to be printed by a trusted or high-end printer, it can be printed anywhere, anytime, and potentially by anyone. The ID verifier uses a single scan process which does not require the use of displays. We detail system's components and present a preliminary performance evaluation using an in-field experiment.

1 Introduction

A typical identity certification such as a driver's licence, passport, or visa, consists of a personal portrait photo, an arbitrary message, and one or more features whose purpose is to guarantee authenticity. Commonly, authenticity is assured using sophisticated printing procedures that are difficult to replicate: holograms, watermarks, micro-printing and threading, special print paper, and chemical coating [1]. However, the wide availability of such technology has rendered forging most personal ID documents a relatively simple task with results often perceptually comparable to the originals. Authentication of imprinted features via electronic devices is complex and most importantly, expensive [1].

In all-digital environments such as smart cards or lasercards [2], authenticating the source of a personal ID is an easy task using off-the-shelf public cryptography [3] and one-way authentication protocols [4]. Typically, the stored photograph as well as other biometric features are concatenated to the textual message and hashed. The resulting hash is then signed using the private key of the issuer. In-field authentication is performed using the public key of the issuer by a verification device (e.g., smart card reader), which also must display the signed data. While the security of such systems can be made to follow even the strictest security standards, the cost of supporting systems makes them undesirable for widespread identity certificate applications such as national ID cards, driver's licences, or passports. A simple smart card costs about \$5-\$35, while a lasercard reader costs about \$2400 [5].

In this paper, we combine best of both worlds into a new technology we call FACECERTS and show how sophisticated specialized compression algorithms can allow the use of paper as an inexpensive hybrid analog/digital domain on which both the human readable information, i.e., text and photo, and the secure digital information can be stored in a way that allows a single-scan verification.